

## 2.7W Mono Filter-less Class-D Audio Amplifier

### Features

- Supply voltage range: 2.5 V to 5.5 V
- Support single-ended or differential analog input
- Low static operation current
- Low shut-down current
- Short power-on transient time
- Internal pull-low resistor on shut-down pins
- Short-circuit protection
- Over-temperature protection
- Loudspeaker power within 10% THD+N
  - 1.66W/ch into 8Ω loudspeaker
  - 2.70W/ch into 4Ω loudspeaker
- Loudspeaker efficiency
  - 90% @ 8Ω, THD+N=10%
  - 85% @ 4Ω, THD+N=10%
- MSOP-8, TDFN-9 and WLCSP-9 packages
- Integrated de-pop circuitry
- Internal generated 450kHz switching frequency

### Applications

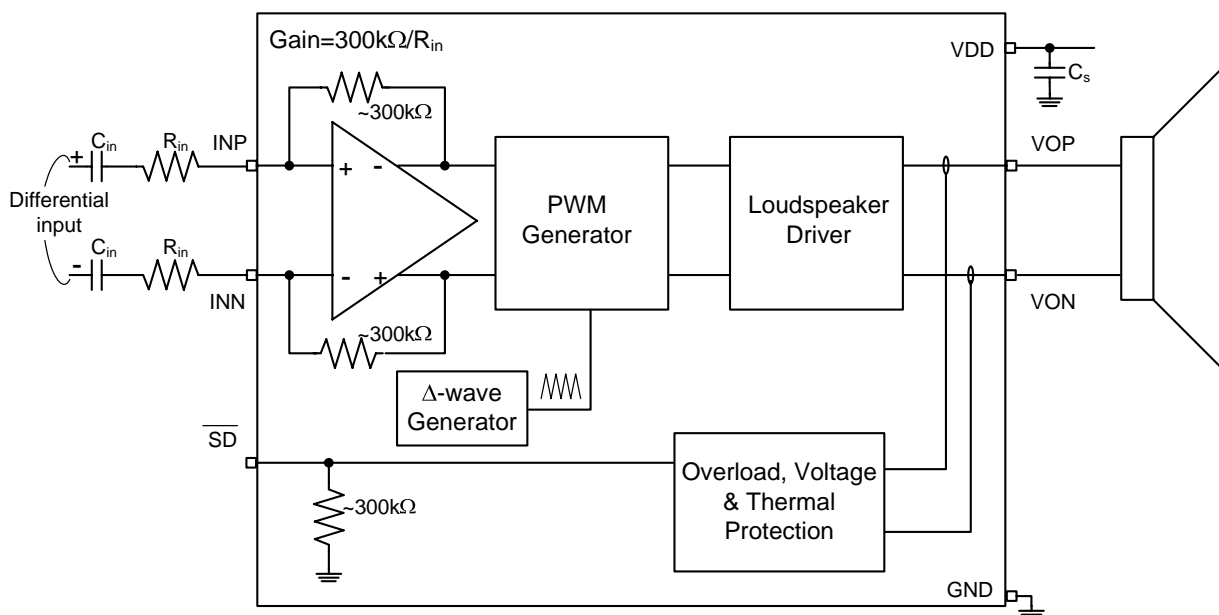
- Monitor audio
- PDA
- Portable multimedia devices
- Notebook computer
- Mobile phone

### Description

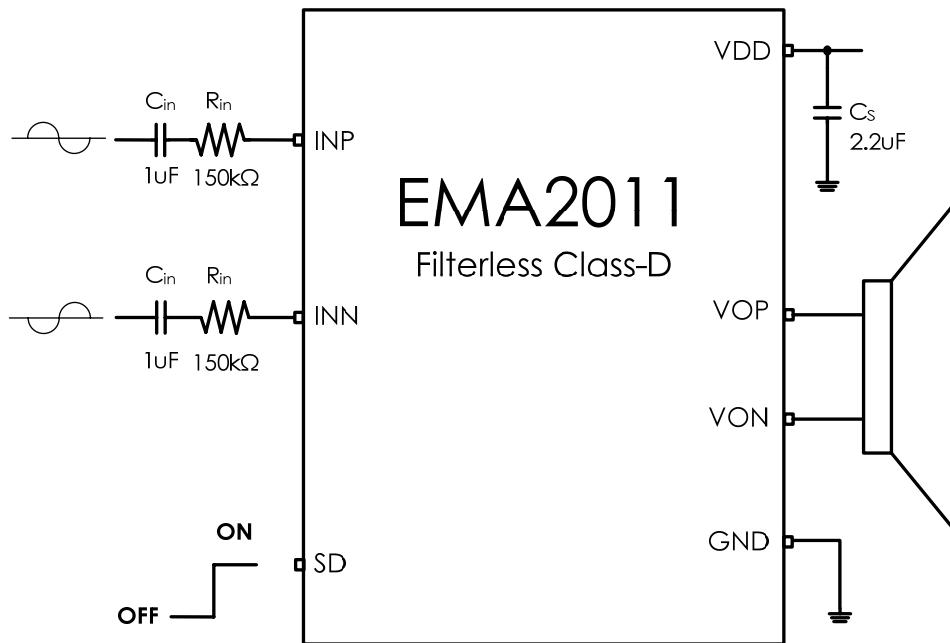
The EMA2011 is a mono, filter-less class-D audio amplifier. Operating with 5.0V loudspeaker driver supply, it can deliver 2.7W output power into 4 Ω loudspeaker within 10% THD+N or 2.2W at 1% THD+N.

The EMA2011 is a mono audio amplifier with high efficiency and suitable for the notebook computer, and portable multimedia device.

### Functional Block Diagram

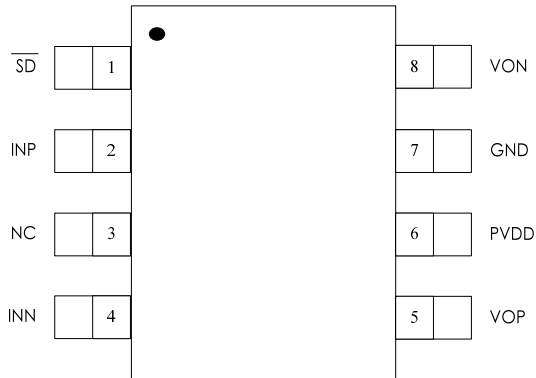


**Typical Application Circuit**



## Pin Assignments

### MSOP-8

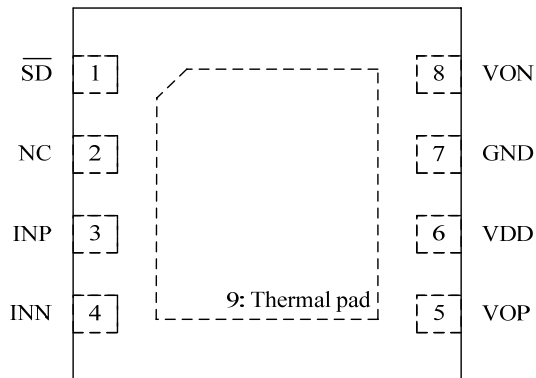


### Order information

EMA2011-50MA08GRR

50 5.0V Operation  
 MA08 MSOP-8 Package  
 GRR RoHS & Halogen free  
 Rating: -40 to 85°C  
 Package in Tape & Reel

### TDFN-8

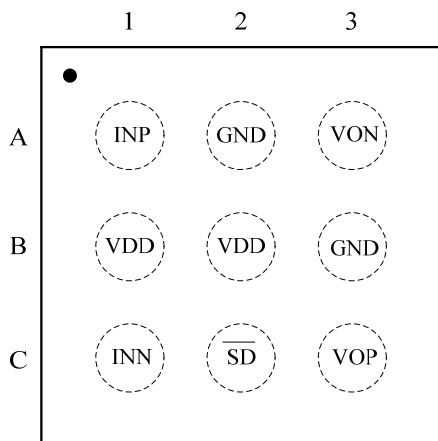


### Order information

EMA2011-50FF08NRR

50 5.0V Operation  
 FF08 TDFN-8 Package  
 NRR RoHS & Halogen free  
 Rating: -40 to 85°C  
 Package in Tape & Reel

### WLCSP-9



### Order information

EMA2011-50WL09GRR

50 5.0V Operation  
 WL09 WLCSP-9 Package  
 GRR RoHS & Halogen free  
 Rating: -40 to 85°C  
 Package in Tape & Reel

## Order, Mark and Packing Information

Package	Product ID	Marking	Packing
MSOP-8	EMA2011-50MA08GRR	<p>Diagram showing the marking on the MSOP-8 package. The package is a square with 8 pins. Pins 1-4 are on the bottom edge, and pins 5-8 are on the top edge. A dot labeled 'PIN1 DOT' is located on the left side of the package. The marking on the package includes 'EMP', 'EMA2011', and 'Tracking code'.</p>	3K units Tape & Reel
TDFN-8	EMA2011-50FF08NRR	<p>Diagram showing the marking on the TDFN-8 package. The package is a square with 8 pins. Pins 1-4 are on the bottom edge, and pins 5-8 are on the top edge. A dot labeled 'PIN1 DOT' is located on the left side of the package. The marking on the package includes 'EMP', 'EMA2011', and 'Tracking Code'.</p>	5K units Tape & Reel
WLCSP-9	EMA2011-50WL09GRR	<p>Diagram showing the marking on the WLCSP-9 package. The package is a square with 3 pins labeled 1, 2, and 3 on the right edge. A dot labeled 'PIN1 DOT' is located on the top edge of the package. The marking on the package includes 'EMP' and 'Tracking Code'. The package is oriented with corners labeled C (top-left), B (top-right), and A (bottom-right).</p>	3K units Tape & Reel

## Pin Description

NAME	PIN			IO TYPE	DESCRIPTION
	MSOP-8	TDFN-8	WLCSP-9		
SD	1	1	C2	I	Shutdown EMA2011 (Low active logic)
INP	2	3	A1	I	Positive differential input
NC	3	2	N/A	NC	No internal connect
INN	4	4	C1	I	Negative differential input
VOP	5	5	A3	O	Positive output
VDD	6	6	B2	P	Power supply
GND	7	7	A2, B3	G	Power ground
VON	8	8	C3	O	Negative output
Thermal pad	N/A	9	N/A	G	Must be connected the package thermal pad to PCB thermal land.

## Available Package

Package Type	Device no.	$\theta_{JA}$ (°C/W)	Exposed Thermal Pad
MSOP-8	EMA2011	190	No
TDFN-8 (3x3mm)		45.8	Yes
WLCSP-9		128	No

## Absolute Maximum Ratings

SYMBOL	PARAMETER	MIN	MAX	UNIT
VDD	Supply for analog cells & loudspeaker driver	2.5	6.0	V
	Input voltage	-0.3	5.5	V
T <sub>stg</sub>	Storage temperature	-65	150	°C
T <sub>a</sub>	Ambient operating temperature	-40	85	°C

## Recommended Operating Conditions

SYMBOL	PARAMETER	MIN	MAX	UNIT
VDD	Supply for analog cells & loudspeaker driver	2.5	5.5	V
V <sub>IH</sub>	High-Level Input Voltage	70% X VDD	VDD	V
V <sub>IL</sub>	Low-Level Input Voltage	0	35% X VDD	V

## General Electrical Characteristics (T<sub>A</sub>=25 °C)

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
I <sub>q</sub>	Operating current	VDD=SD=5V		5.7		mA
I <sub>PD</sub>	Supply current during power-down mode	VDD=5.0V; SD#=0		0.5	1	μA
V <sub>offset</sub>	Output offset voltage	Input ac grounded, VDD=2.5V ~ 5.0V		5	25	mV
T <sub>sd</sub>	Junction temperature for driver shutdown		145	150	155	°C
T <sub>hys</sub>	Temperature hysteresis for recovery from shutdown		115	120	125	°C
f <sub>sw</sub>	Switching rate of loudspeakers driver		300	450	600	kHz
T <sub>on</sub>	Turn-on time	VDD = 3.6 V		1	4	msec
R <sub>sc</sub>	Loudspeaker short-circuit detect resistance	VDD = 5.0 V		2.8	3.2	ohm

## Electrical Characteristics and Specifications for Loudspeaker

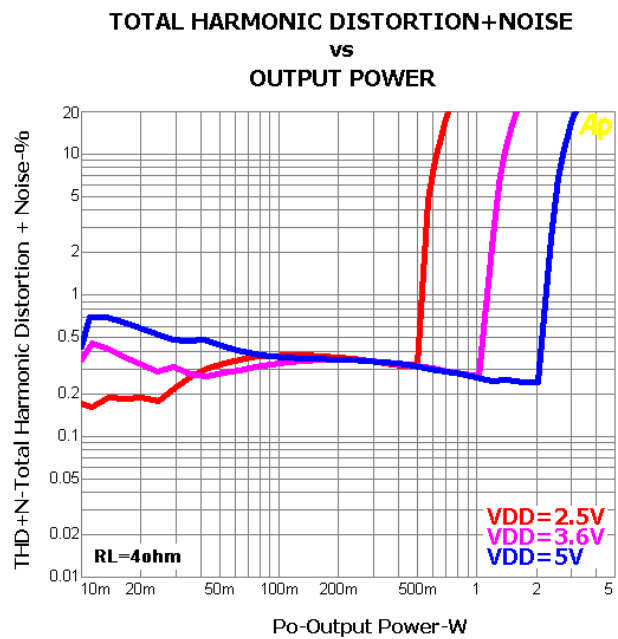
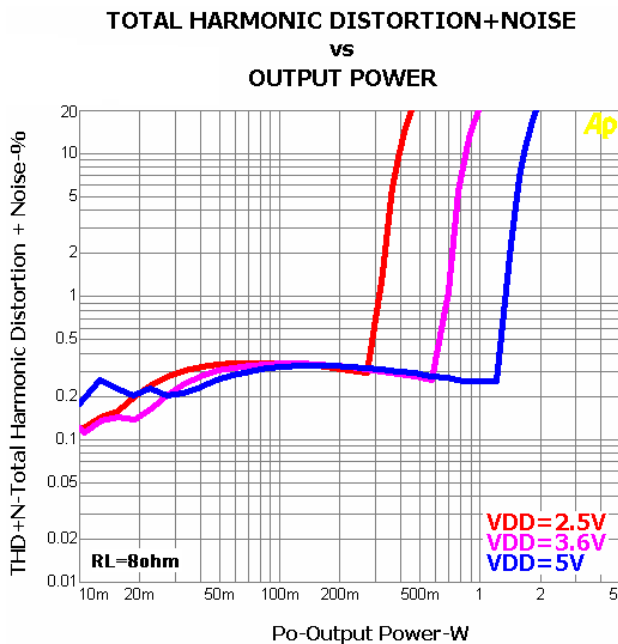
- Gain= 2 V/V, Load=8Ω, f<sub>in</sub>=1 kHz (unless otherwise noted)

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
P <sub>O</sub>	RMS Output Power	VDD=5.0V	THD+N = 10 %		1.66	W
			THD+N = 1 %		1.35	W
		VDD=3.6V	THD+N = 10 %		0.85	W
			THD+N = 1 %		0.68	W
		VDD=2.5V	THD+N = 10 %		0.39	W
			THD+N = 1 %		0.31	W
THD+N	Total Harmonic Distortion plus Noise	VDD=5.0V, P <sub>o</sub> =1.0W		0.24	%	
		VDD=3.6V, P <sub>o</sub> =0.5W		0.34	%	
		VDD=2.5V, P <sub>o</sub> =0.2W		0.4	%	
SNR	Signal to Noise Ratio	VDD=5.0V, P <sub>o</sub> =1.0W		94	dB	
PSRR	Power Supply Rejection Ratio	VDD=3.6V, V <sub>ripple</sub> =200mVpp Inputs ac grounded with C <sub>i</sub> =2μF f=217 Hz		-60	dB	
CMRR	Common-Mode Rejection Ratio	VDD=3.6V, V <sub>IC</sub> =1Vpp, f=217Hz		-50	dB	
V <sub>n</sub>	Output integrated noise (A-weighted)	VDD=3.6V f <sub>in</sub> =20Hz ~ 20kHz		80	μV	
η	Efficiency	VDD=5V, THD+N=10%		88.5	%	

- Gain= 2 V/V, Load=4Ω,  $f_{in}$ =1 kHz (unless otherwise noted)

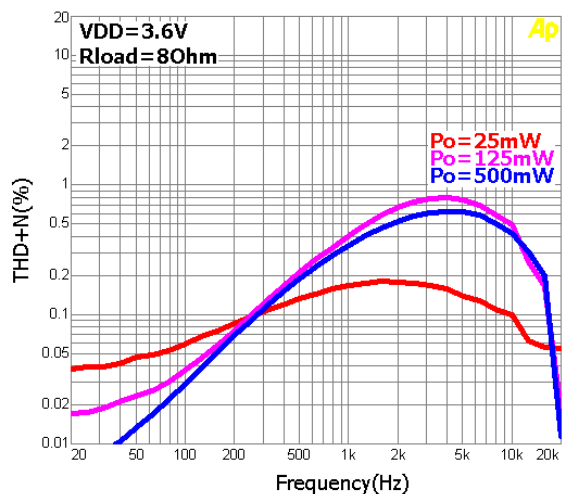
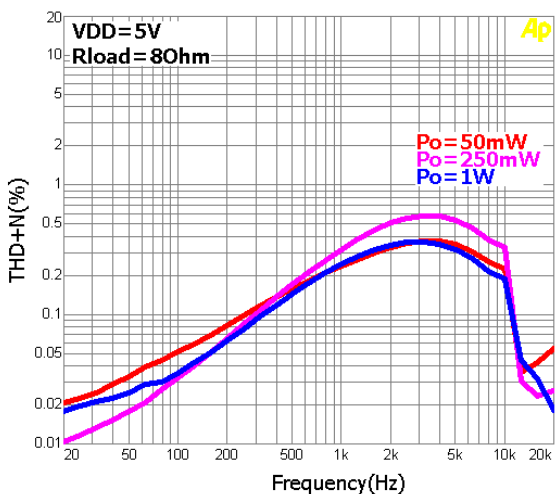
SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT	
P <sub>o</sub>	RMS Output Power	VDD=5.0V	THD+N = 10 %		2.7		W
			THD+N = 1 %		2.2		W
		VDD=3.6V	THD+N = 10 %		1.3		W
			THD+N = 1 %		1.1		W
		VDD=2.5V	THD+N = 10 %		0.6		W
			THD+N = 1 %		0.5		W
THD+N	Total Harmonic Distortion plus Noise	VDD=5.0V, P <sub>o</sub> =2.0W			0.24		%
		VDD=3.6V, P <sub>o</sub> =1.0W			0.34		%
		VDD=2.5V, P <sub>o</sub> =0.5W			0.4		%
SNR	Signal to Noise Ratio	VDD=5.0V, P <sub>o</sub> =1.8W			94		dB
PSRR	Power Supply Rejection Ratio	VDD=3.6V, V <sub>ripple</sub> =200mVpp Inputs ac grounded with C <sub>i</sub> =2μF f=217 Hz			-60		dB
CMRR	Common-Mode Rejection Ratio	VDD=3.6V, V <sub>IC</sub> =1Vpp, f=217Hz			-55		dB
V <sub>n</sub>	Output integrated noise (A-weighted)	VDD=3.6V f <sub>in</sub> =20Hz ~ 20kHz			83		μV
η	Efficiency	VDD=5.0V, THD+N=10%			80		%

## Typical Characteristics (Gain= 2 V/V, unless otherwise noted)



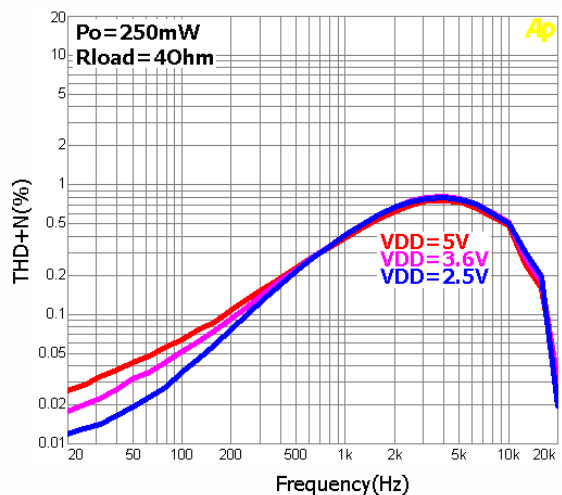
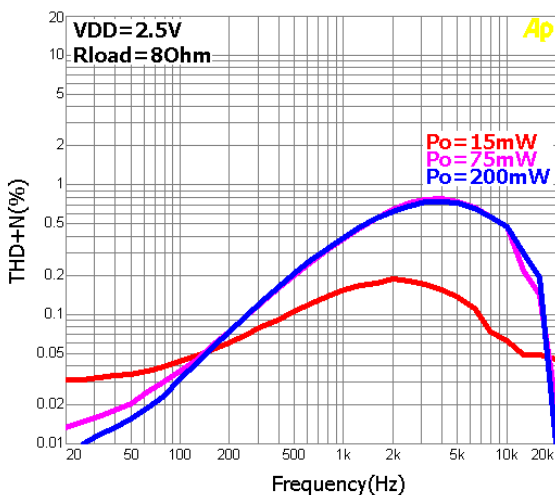
Total Harmonic distortion +Noise(THD+N) vs Signal Frequency

Total Harmonic distortion +Noise(THD+N) vs Signal Frequency



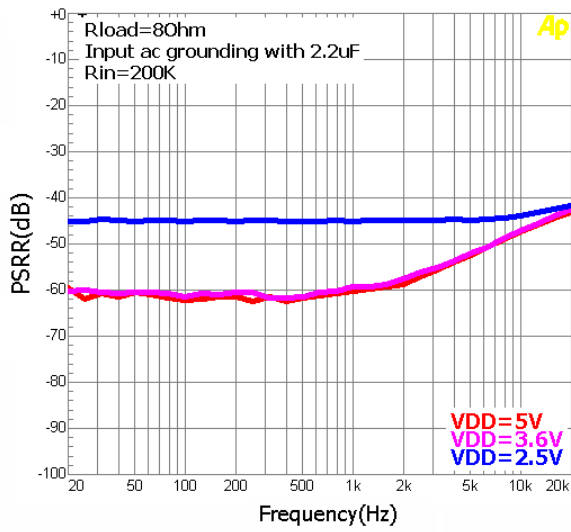
Total Harmonic distortion +Noise(THD+N) vs Signal Frequency

Total Harmonic distortion +Noise(THD+N) vs Signal Frequency

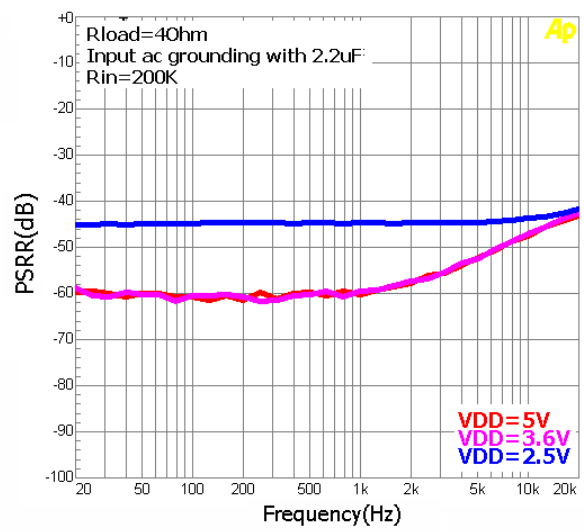




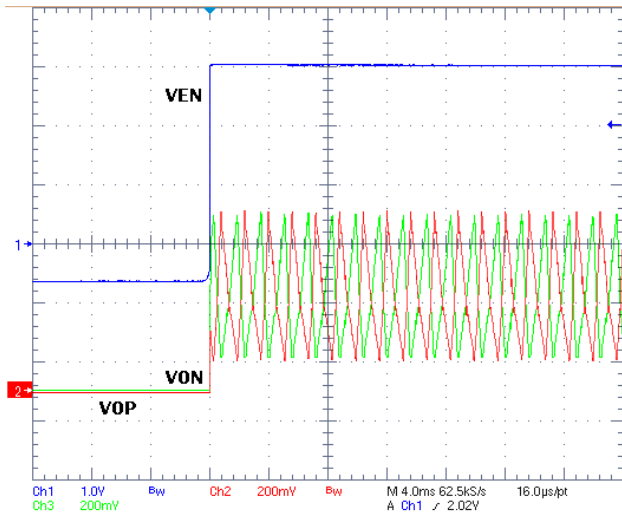
Power Supply Rejection Ratio



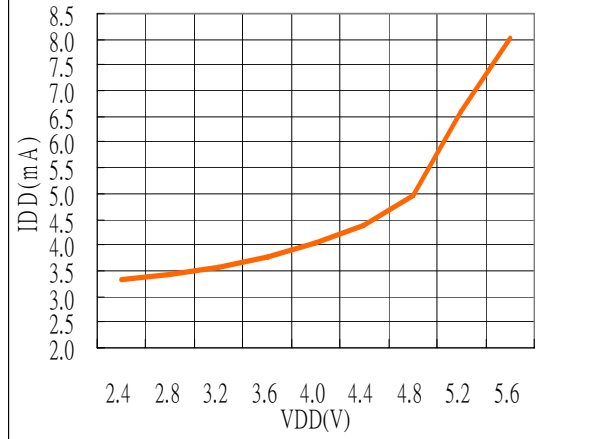
Power Supply Rejection Ratio



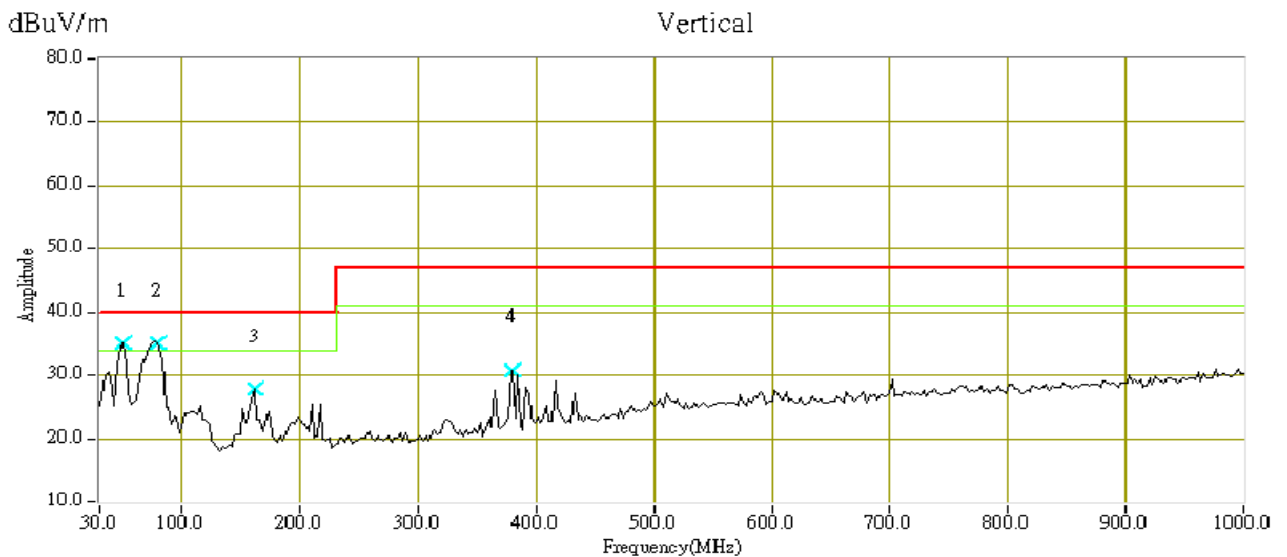
Turn-On time



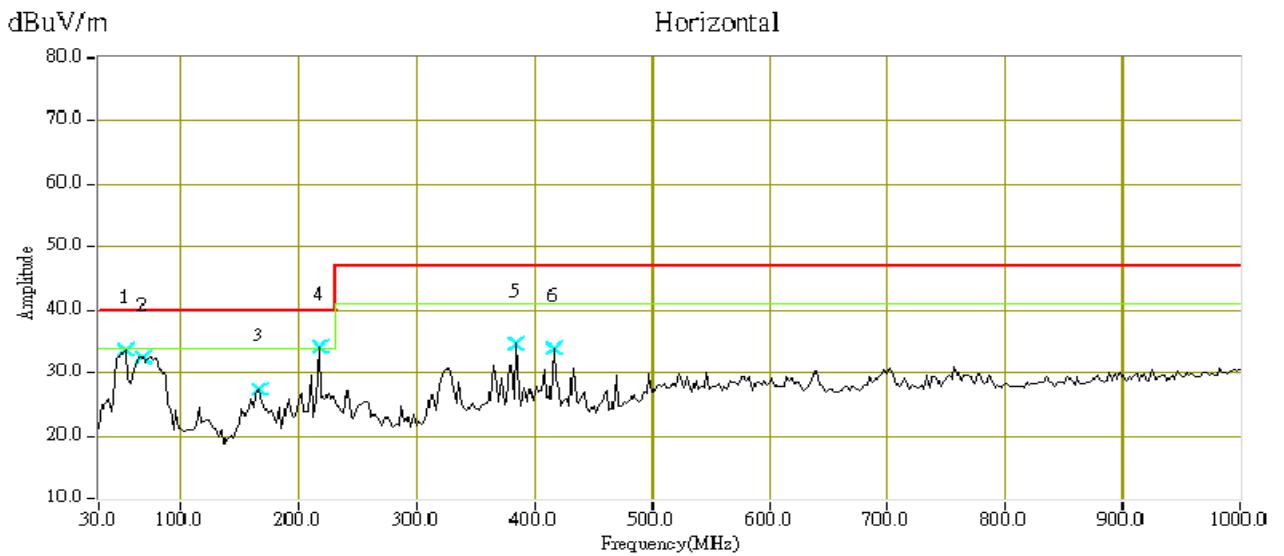
IDD vs VIN (RL= 8 Ω)



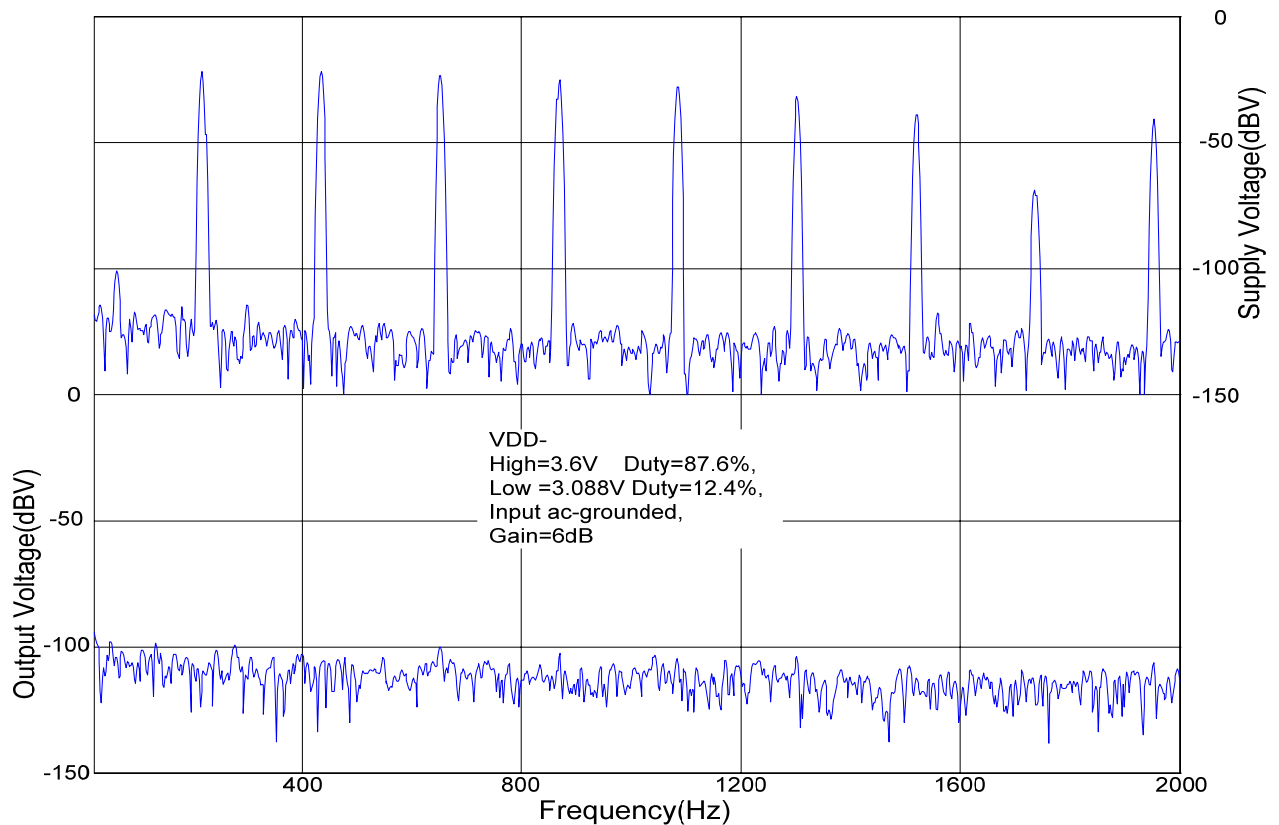
● EMI Test – CISPR22 Class B (Vertical)



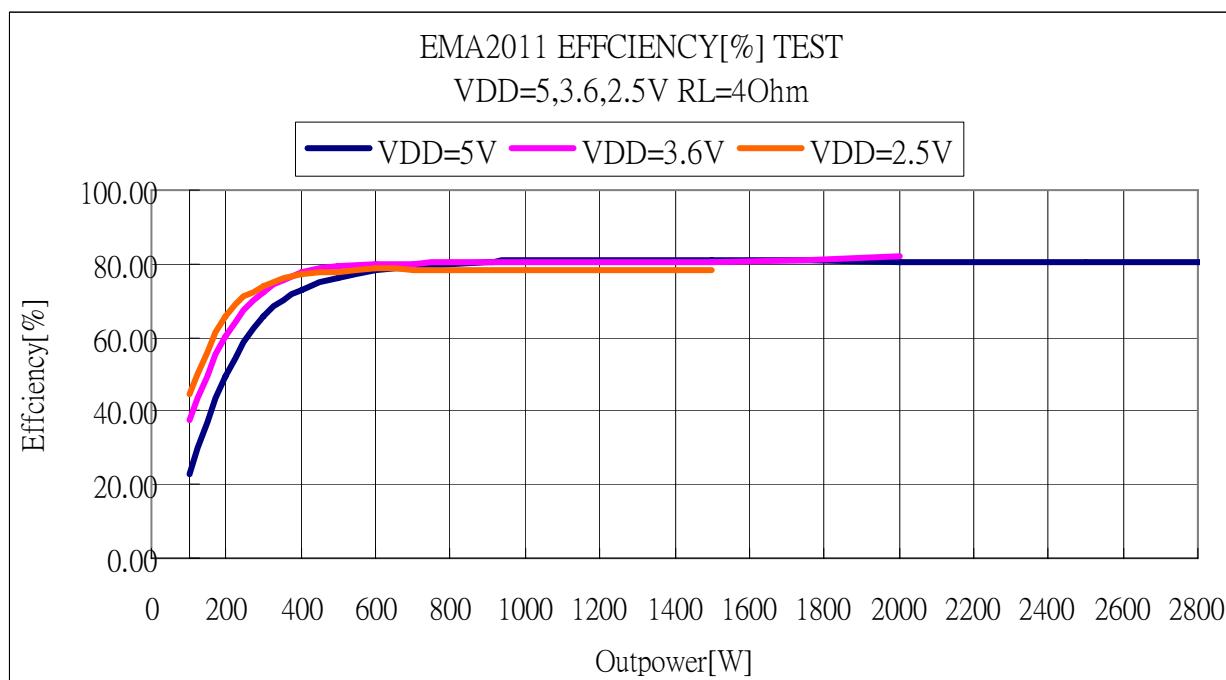
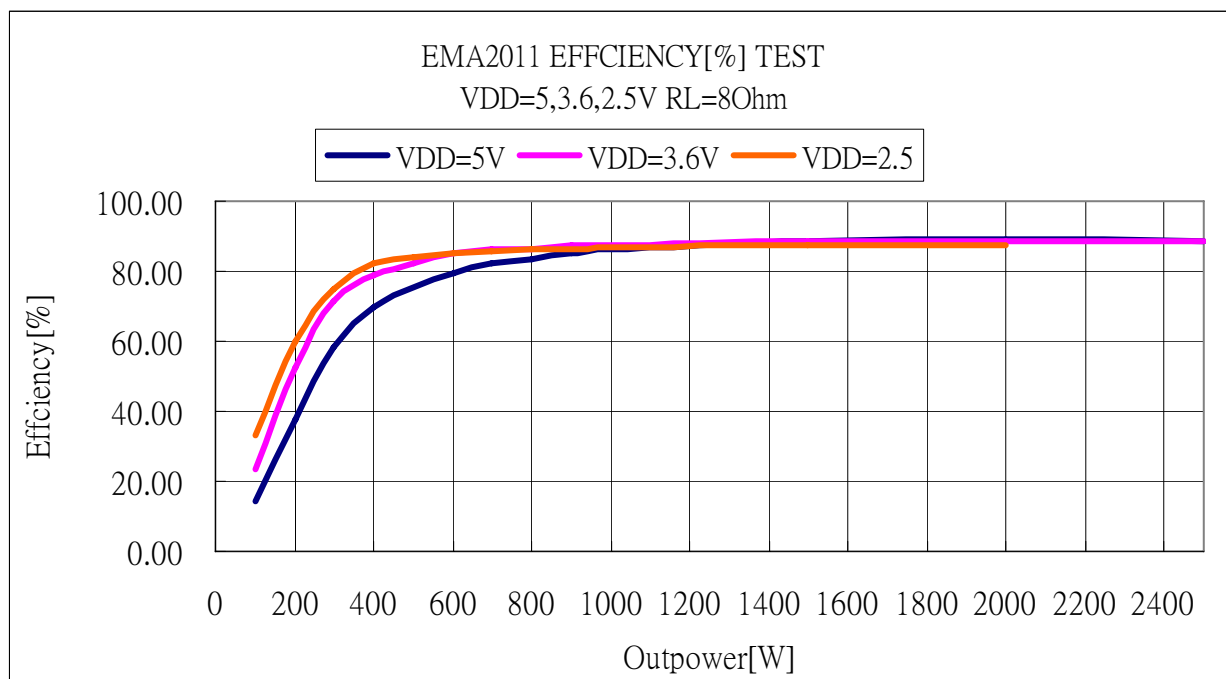
- EMI Test – CISPR22 Class B (Horizontal)



- GSM Power Supply Rejection vs Frequency



● Efficiency



**Operation Descriptions**

- Self-protection circuits (Typical values are used below.)

EMA2011 has built-in over-temperature, overload and under-voltage detectors.

- If the internal junction temperature is higher than 150°C, the outputs of loudspeaker drivers will be disabled and connected to ground and the temperature hysteresis for EMA2011 to return to normal operation is about 30°C. The variation of protected temperature is around 10%.
- To protect loudspeaker drivers from current damage when the wires connected to loudspeakers are shorted to one another or shorted to GND, circuits for the detection of output loading are built in the EMA2011. For normal operation, loudspeaker resistance is larger than 3.2Ω is required. Otherwise, overload detectors may activate. Once overload detector is active, loudspeaker drivers will be disabled and at low state. EMA2011 will be recovery from overload fault by pulling SD# down to low and back to high after removing the short. Once the lines connected to loudspeakers are shorted to VDD, EMA2011 will be burnt.
- When the VDD voltage is lower than 2.1V, EMA2011 will disable and loudspeaker drivers are at low state, cease EMA2011 beside voltage detector circuit. When VDD becomes larger than 2.2V, EMA2011 will return to normal operation.

- Anti-pop design

EMA2011 is with anti-pop design. Annoying pop sounds during initial power on and power down/up are suppressed. When one of the operations mentioned above is applied, EMA2011 will internally generate appropriate control signals to suppress pop sounds.

**Application Circuit Information**

- Input resistors ( $R_{in}$ ) and input capacitors ( $C_{in}$ )

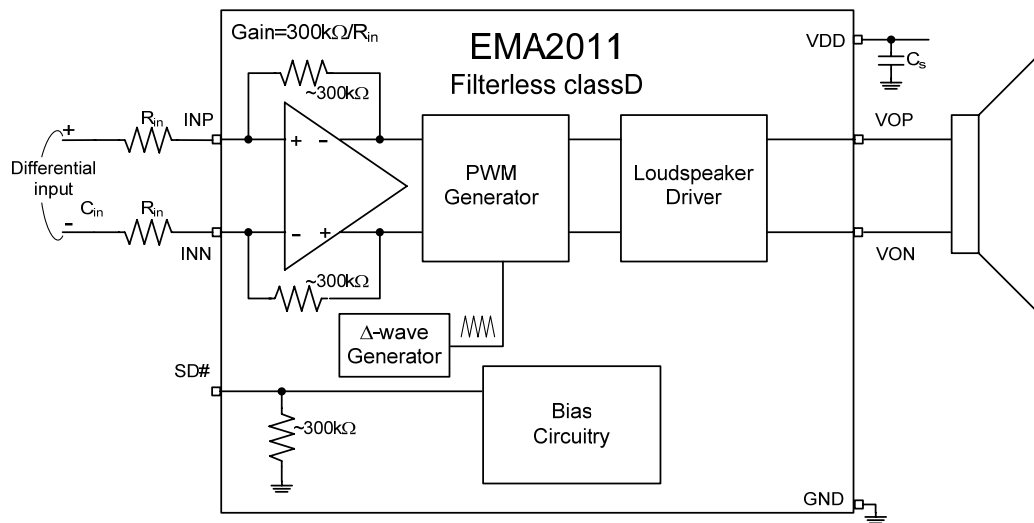
The total gain of the audio amplifier (EMA2011) is set by input resistor ( $R_{in}$ ) according to the following equation (a). The performance at low frequency (bass) is affected by the corner frequency ( $f_c$ ) of the high-pass filter composed of input resistors ( $R_{in}$ ) and input capacitors ( $C_{in}$ ), determined in equation (b).

$$Gain = \frac{300k\Omega}{R_{in}} \left( \frac{V}{V} \right) \dots \dots \dots (a)$$

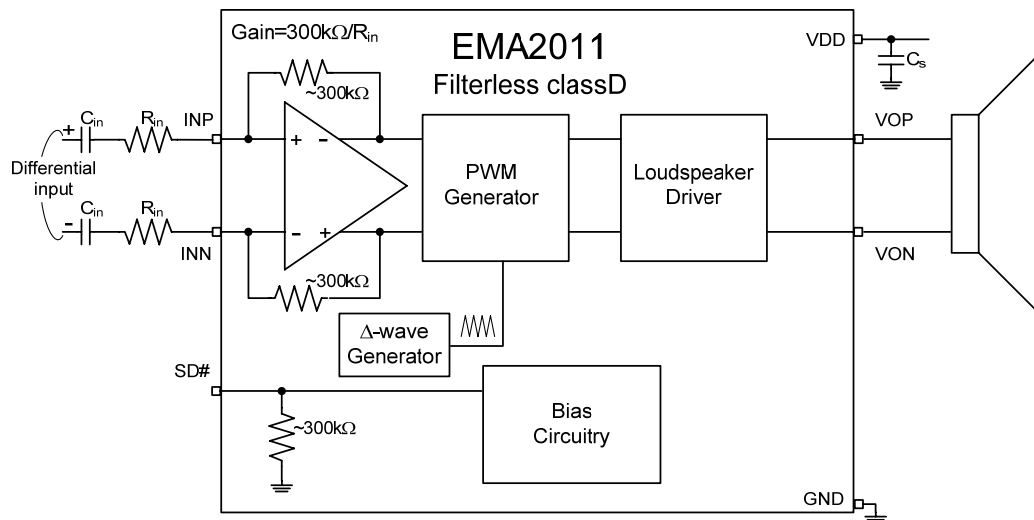
$$f_c = \frac{1}{2\pi R_{in} C_{in}} \text{ (Hz)} \dots \dots \dots (b)$$

For differential audio signal application, the input capacitors ( $C_{in}$ ), for DC decoupling, are not required. When single-ended audio source is used, the input capacitors ( $C_{in}$ ) are required.

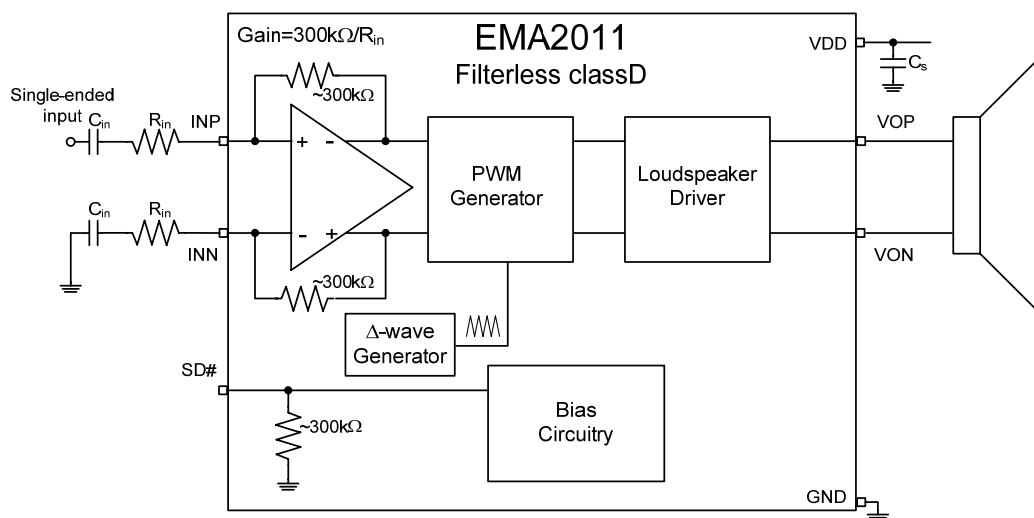
- Cost effective application circuit for fully differential input



- Suggested application circuit for fully differential input

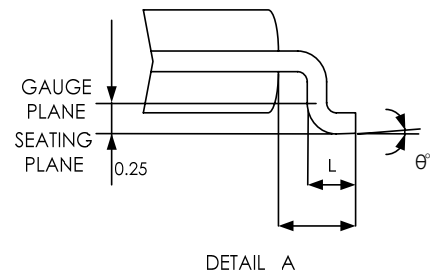
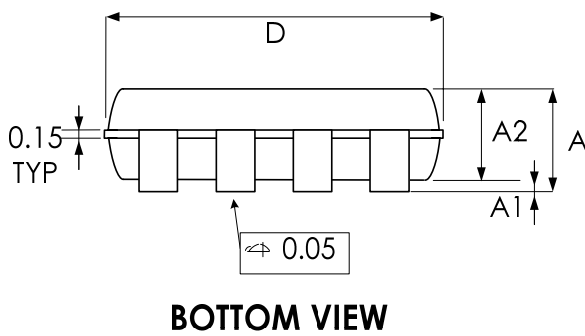
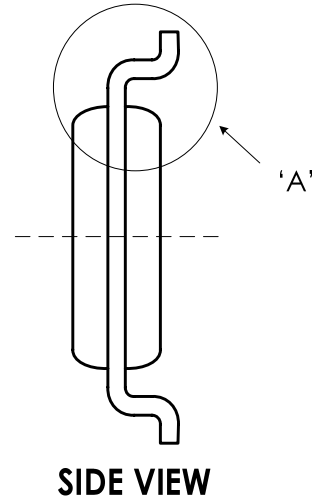
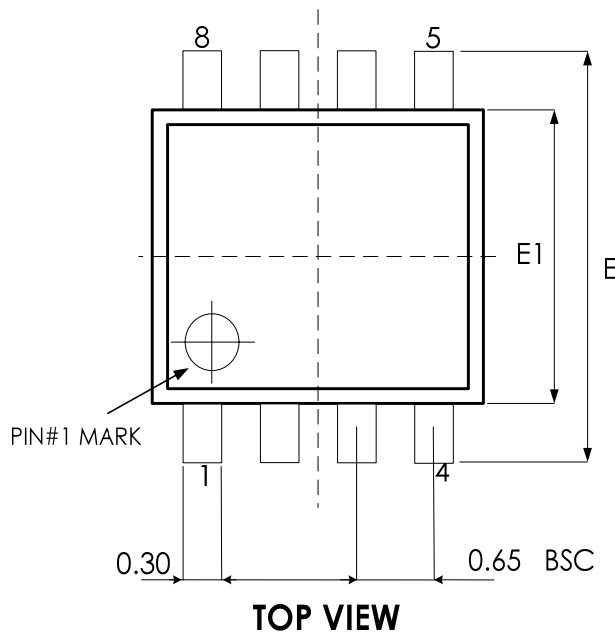


- Suggested application circuit for single-ended input



## Package Dimensions

### ● MSOP - 8L

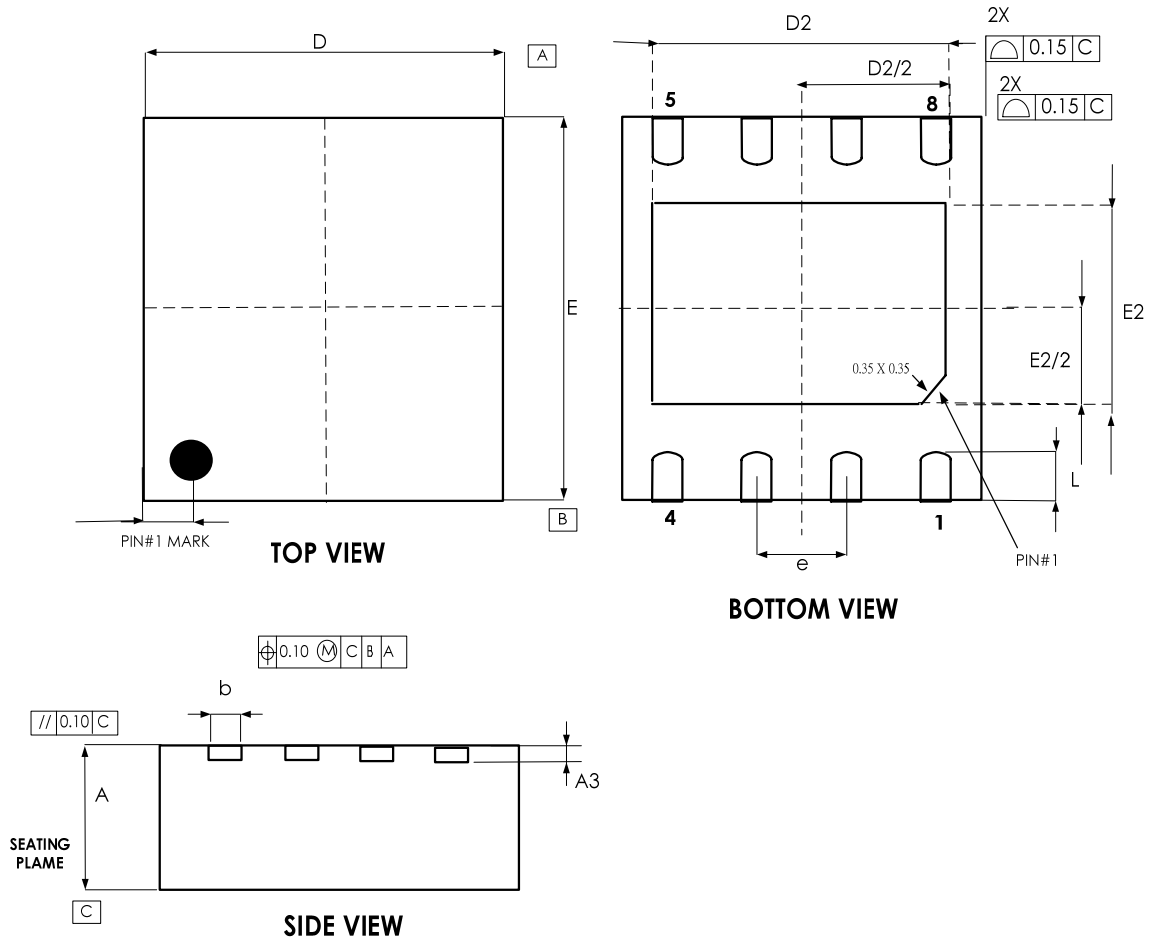


SYMBPLS	MIN.	NOM.	MAX.
A	—	—	1.1
A1	0	—	0.15
A2	0.75	0.85	0.95
D	3.00 BSC		
E	4.90 BSC		
E1	3.00 BSC		
L	0.4	0.6	0.8
L1	0.95 BSC		
θ°	0	—	8

UNIT: mm

## Package Dimensions

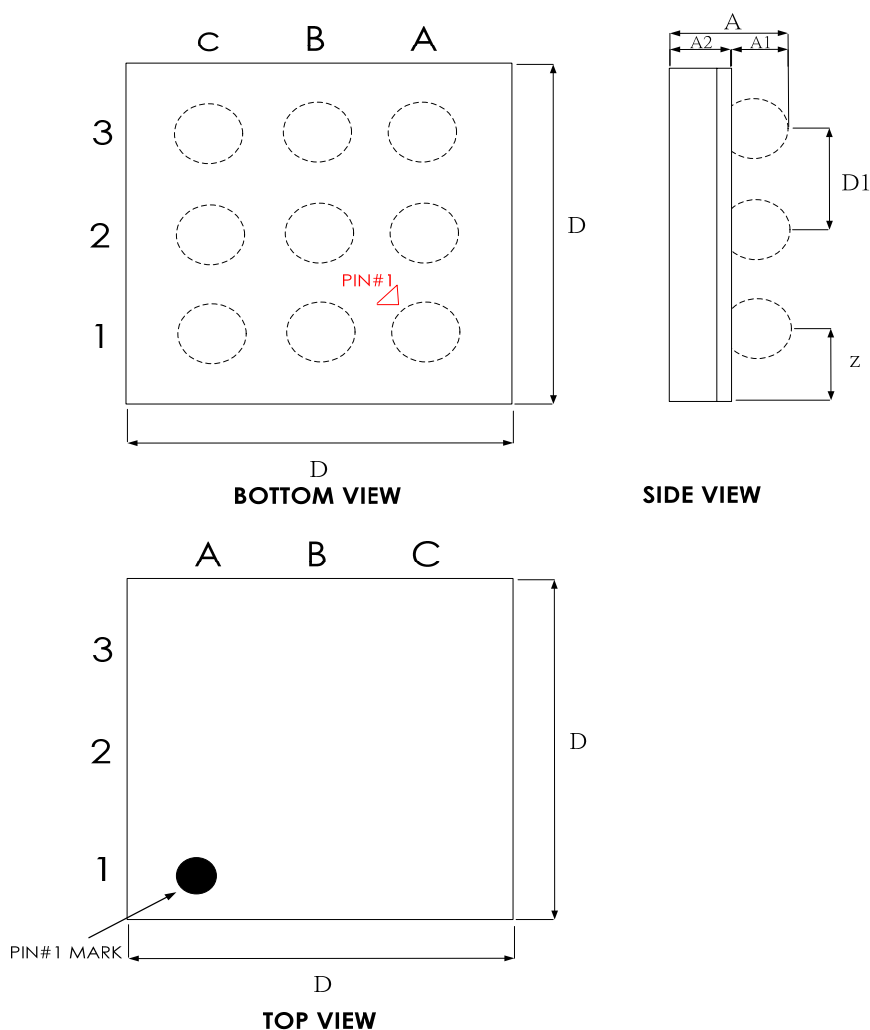
### ● TDFN - 8L (3x3x.75 mm)



SYMBOL	COMMON					
	DIMENSIONS MILLIMETER			DIMENSIONS INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.027	0.029	0.031
A3	0.203 BSC			0.008 BSC		
b	0.25	0.30	0.35	0.009	0.011	0.013
D	2.85	3.00	3.15	0.111	0.117	0.122
D2	2.20	2.30	2.40	0.085	0.089	0.093
E	2.85	3.00	3.15	0.111	0.117	0.122
E2	1.50	1.60	1.70	0.058	0.062	0.066
e	0.650 BSC			0.024 BSC		
L	0.30	0.35	0.40	0.011	0.013	0.015

## Package Dimensions

- WCSP - 9L (1.45x1.45 mm)



Symbol	Dimensions in millimeter		
	min.	typ.	max.
A	0.585	0.650	0.715
A1	0.210	0.235	0.260
A2	0.355	0.380	0.405
D	1.420	1.460	1.500
D1	0.50		
Z	0.23		



## Revision History

Revision	Date	Description
2.0	2009.05.08	EMP transferred from version 1.3
2.1	2010.07.29	To correct the pins of VOP & VON described mistake for all page.
2.2	2013.6.17	To revise a. WLCSP prdduct-id as EMA2011-50WL09GRR b. MSOP GRR definition
2.3	2013.7.24	Revise IPD max spec to 1uA

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